



PIARC Global Road Safety Knowledge Exchange Road Tunnels

Summary

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- **Specific Hazards in Road Tunnels**
- **Human Factors for Road Tunnels Safety**
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About PIARC



PIARC

World Road Association

- Founded in **1909** as a non-profit, non-political Association
- Foster and facilitate global discussion and **knowledge sharing on roads and road transport**
- **124 government members** worldwide
- Retains **consultative status** to the Economic and Social Council of the **United Nations**
- **4 Strategic themes**: ST1 road administration, ST2 mobility, ST3 safety and sustainability, ST4 resilient infrastructure
- **16 Technical Committees (TCs)**, 4 per strategic theme, unite experts from numerous areas including road safety and design, network operations and maintenance, finance and governance.



PIARC Road Safety Technical Committee

Technical Committee T.C. 3.1: Road Safety part of ST3:

- Observes specific **road safety issues for LMICs**
- Explores the implementation of **proven countermeasures**
- Updates the “**Road Safety Audit Guidelines**” and the “**Road Safety Manual**”
- Disseminates and encourages the **application of the manuals**
- Provides **access to well-chosen safety measures** and their dissemination among **LMICs**
- Studies the implications of **connected and automated vehicles**

PIARC Road Safety Activities

- **Technical reports** prepared by the Technical Committees
 - Well-Prepared Projects
 - Automated Vehicles – Challenges and Opportunities for Road Operators and Road Authorities
- **Road Safety Manual:** an electronic manual for all technicians and managers concerned about road safety issues **acknowledged by the United Nations**
- **Seminars** organised by the Association available online
 - Connected and Autonomous Vehicles, a Pathway towards a Safer Future, 27-28 October 2021
 - Road Safety in Low to Middle Income Countries, 18-20 May 2021
- Declaration of **Support** to the **UN Decade of Action**

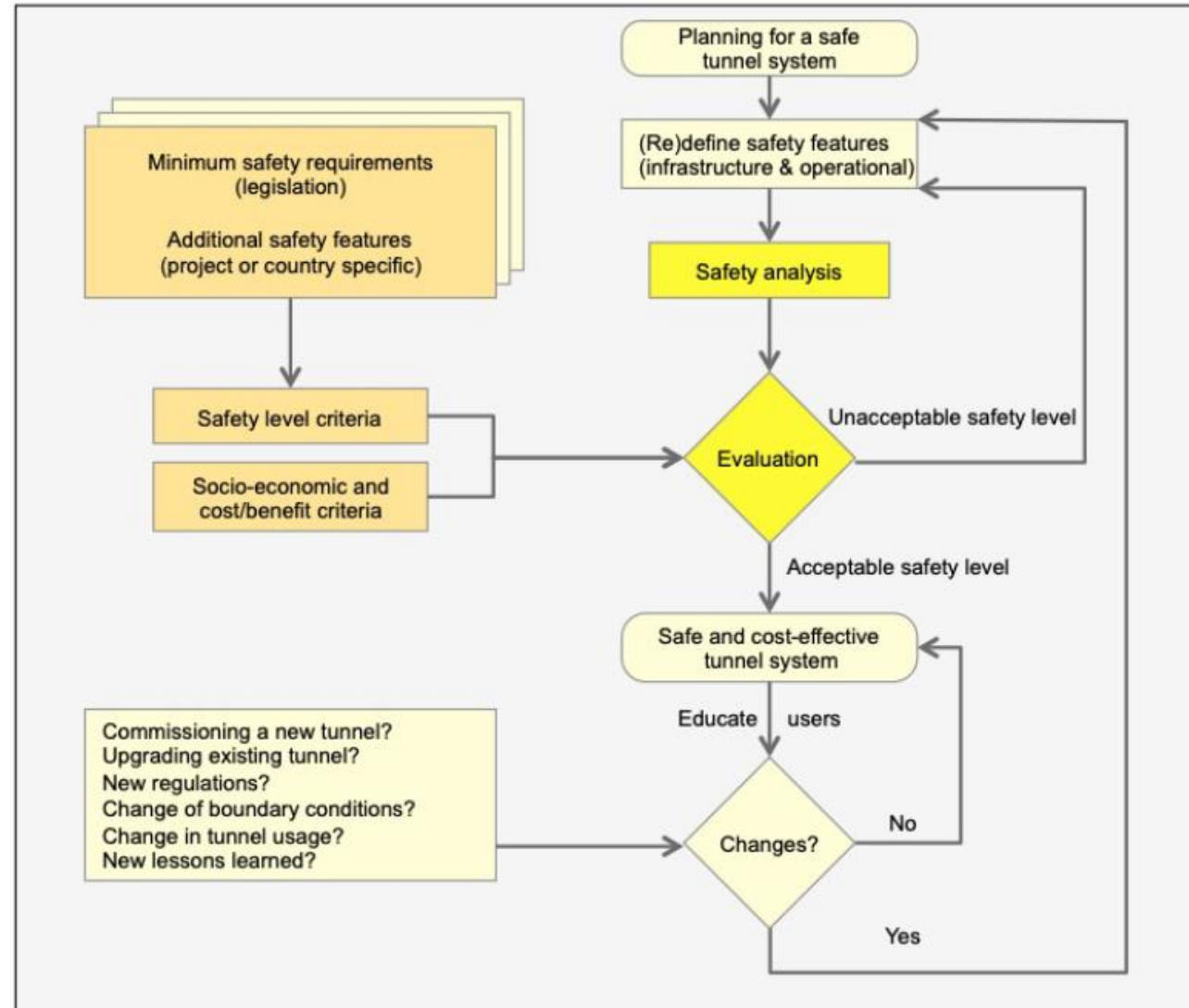
PIARC Global Road Safety Knowledge Exchange Project

- Aiming to **promote knowledge sharing** through appropriate implementation aids that will reflect previous work of but not limited to PIARC
- Focus on spreading road safety knowledge to **Low- and Middle-Income Countries**, where **death rates** due to road traffic injuries in LMICs are **three times higher** than in high-income countries (HIC).
- With the support of National Technical University of Athens (**NTUA**) and Austrian Institute of Technology (**AIT**)
- Deliverables for this project include **fact sheets, presentations**. Based on the road safety manual and other relevant **material produced by PIARC** technical committees (reports, case studies etc.).

Road Tunnels Safety Principles



Integrated Approach



Aspects of tunnel safety

- **Safety level criteria** – Regulations and recommendations
- **Infrastructure** and operational measures
- **Socio-economic** and **cost-benefit** criteria
- **Safety assessment** techniques (risk analysis and evaluation)
- Road tunnel **usage**
- **Stage of tunnel life** (planning, design, construction, commissioning, operation, refurbishment, upgrade)
- Operating **experience**
- **Tunnel system condition**

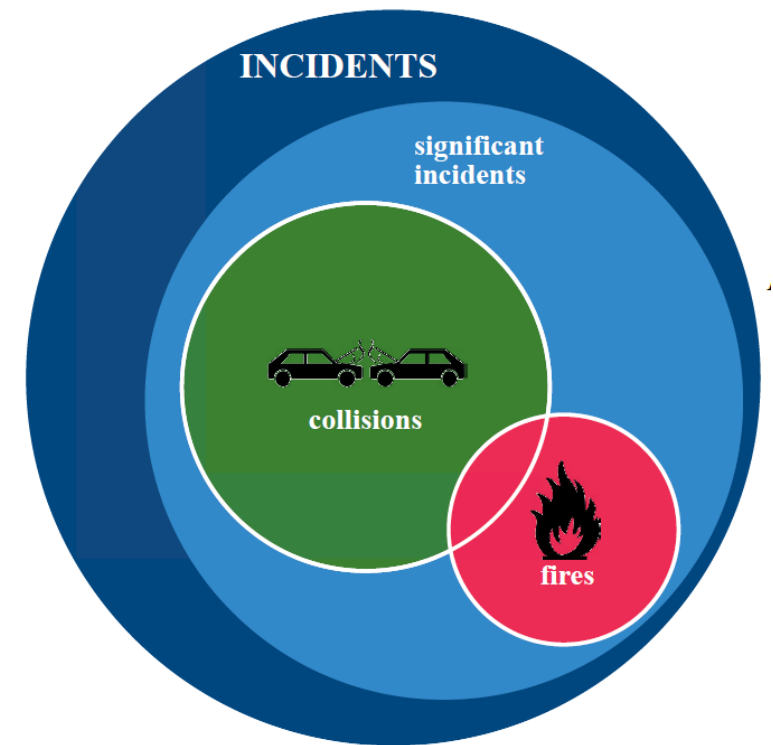
Specific Hazards in Road Tunnels



Significant incidents in road tunnels

Incidents which require special attention, because they are, or have the potential to develop into, events with serious consequences to the health or life of people, to property, to infrastructure or to the environment, or are valuable for further evaluation with respect to underlying basic risk factors.

- **Collisions**
- **Fires**
- **Release of dangerous goods**



Tunnel Collisions

Positive factors reducing the probability of collision in tunnels:

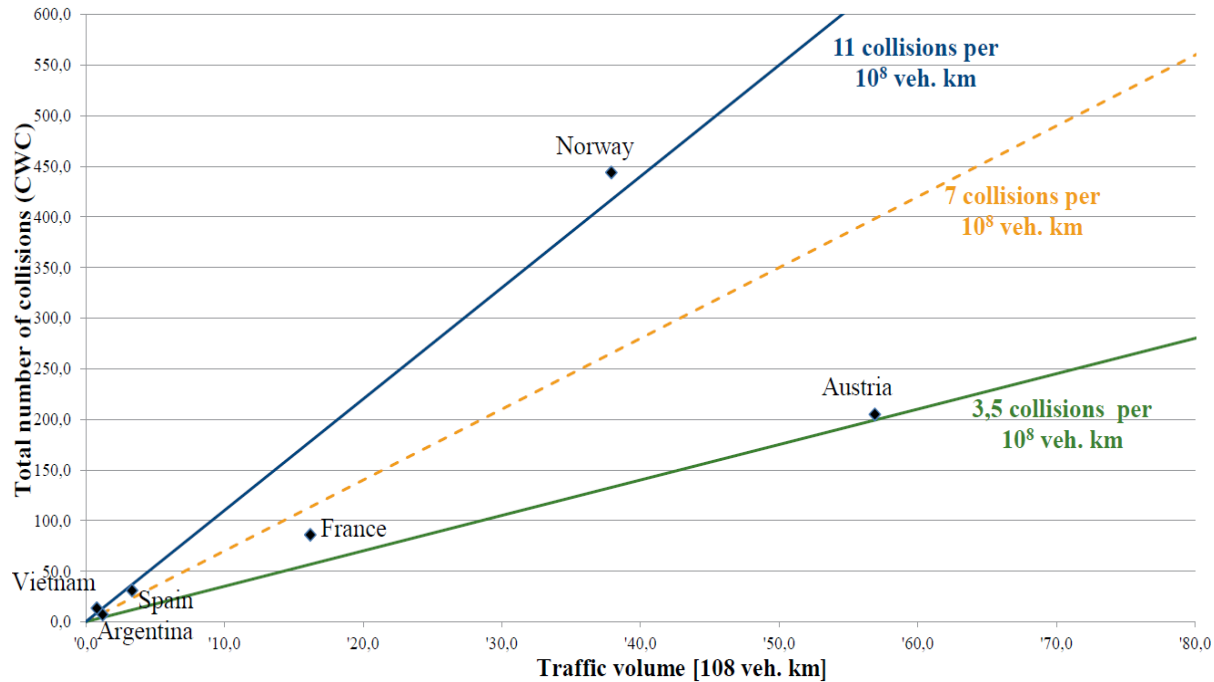
- **Environmental conditions** are better controlled within tunnels
- Tunnels provide a **shorter and safer route**, with fewer (or no) junctions, interchanges, crossroads and intersections
- **Pedestrians and slow moving vehicles** are generally **prohibited** in road tunnels

Tunnel Collisions

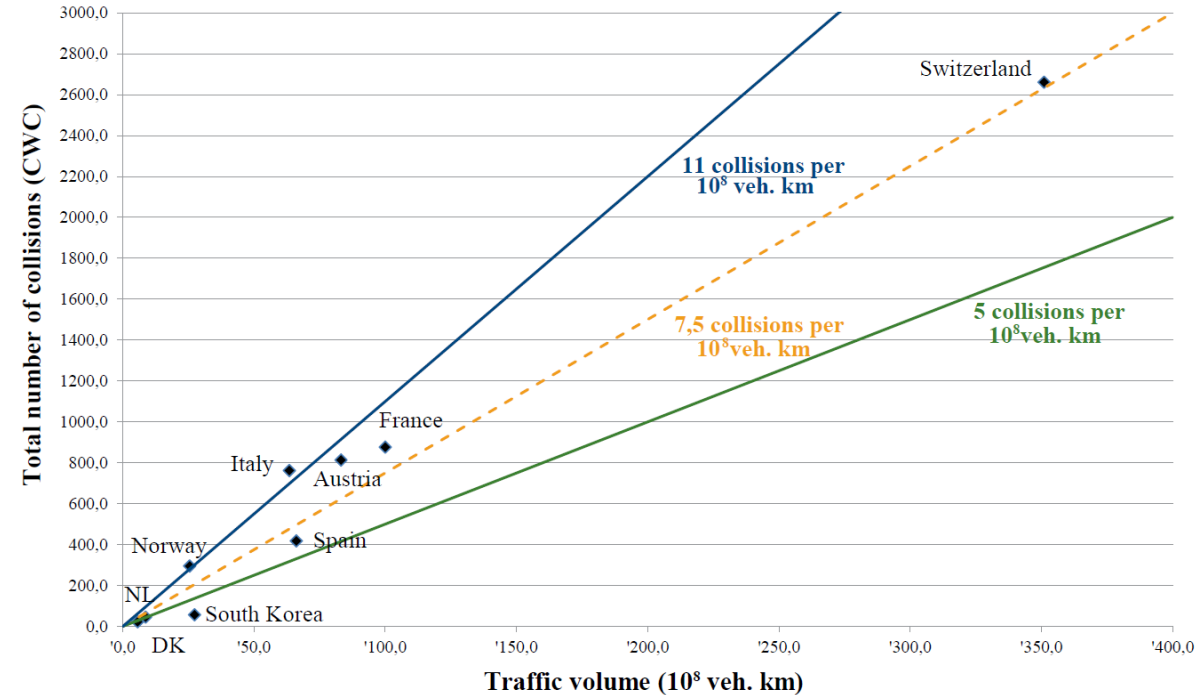
Negative factors increasing the probability of collision in tunnels:

- **Proximity of stationary obstacles** (like tunnel portals, road signs, tunnel wall) may influence driving behavior
- **Protective measures** typical for open road sections (e.g. barriers) are **not present** in all tunnels
- **Emergency lanes** are **not present** in many motorway tunnels
- **Sudden changes in light conditions** may occur at tunnel portals
- The **monotonous atmosphere** of long tunnels may hamper a driver's awareness
- **Tunnel conditions** may cause **misjudgment** of horizontal and vertical **alignment**, as well as of **safe driving distance** from other vehicles and obstacles

Tunnel Collisions statistics



Total number of collisions in the records shown in relation to the corresponding traffic for various countries – reference line for collision rates in bidirectional tunnels



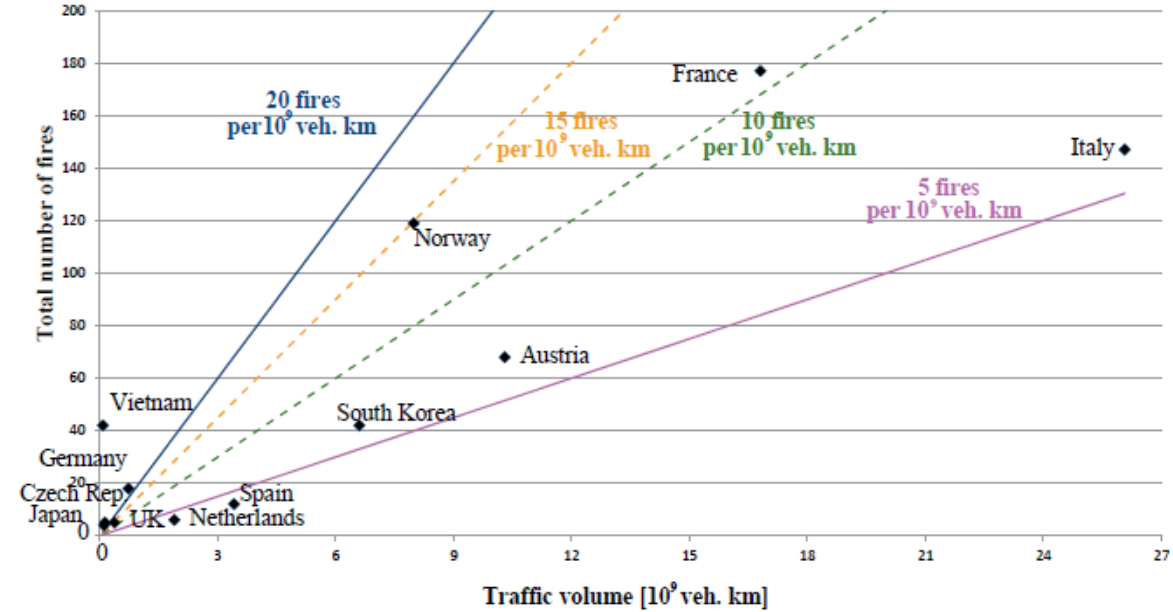
Total number of collisions in the records shown in relation to the corresponding traffic for various countries – reference line for collision rates in unidirectional tunnels

Tunnel Fires

- **Key parameters** for the characterization of tunnel fire:
 - **Speed** of fire development
 - **Fire size**
- **Key factors influencing** tunnel fires:
 - Nature of **fire load**
 - **Technical conditions** of the vehicles involved
 - **Airflow conditions** in the tunnel during fire development
 - **Fire safety engineering design** of the specific tunnel

Types of Tunnel Fires

- **Fires resulting from vehicle defect**
 - **Shielded fires**
 - **Develop slowly**
 - **Increased opportunity to be extinguished** before threatening the health and safety of people in the tunnel
- **Fires after collision:**
 - **Accelerated** by (limited amounts of) **fuel** leaked after the collision
 - **Faster development**



Total number of fires in the records shown in relation to the corresponding traffic for various countries – reference lines for fire rates

Human Factors for Road Tunnels Safety



Tunnel users

- The design of tunnels and their operation should **take account of human factors**
- Tunnels are enclosed structures with **confined space**, that can cause, for some users, **feelings of anxiety** and particular behavior especially at the event of a collision
- **Drivers** need to be more **aware of how they should behave** in tunnels
- A fairly long stretch of road (**150-200m**) **before the tunnel** should **not contain too many signs** or signals
- The **tunnel safety facilities** should be **easily recognizable** even in normal traffic
- **Alarm signals** should be provided **by multiple-redundant sources** (e.g. public address system and variable message signs)
- **Measures implemented** should be **well understood** and adopted by the users

Tunnel Operators

- Operating staff responsible for **monitoring and controlling tunnels**
- Involved in road **tunnels crisis management**
- **Inform and warn users in real time**, encouraging them to adopt the appropriate behavior
- Specific and appropriate **training is essential**
- **Good coordination with rescue teams** is required
- In **cross-border tunnels** collaboration between concerned countries is required

Real-time Communication with users

- Traffic lights
- Lane control signals
- Tunnels lighting
- Variable message signs
- Radio messages
- Mobile phones
- Tunnel closure systems
- Public address systems
- Evacuation route lighting
- Emergency phones flashing exit route/location indicators
- Sirens
- Sound beacons above emergency exits
- Videophones
- In-vehicle systems

Tunnel operators and emergency services needs

- Organize **consultation and cooperation** during the tunnel design process
- Construct **contingency plans** in order to prepare for tunnel user protection and fire fighting operations and to keep these plans up-to-date
- Organize **familiarization visits** to tunnels and arrange exercises to test operational training
- Define **measures** necessary to minimize the time required to mobilize the emergency services
- Organize **post accident analysis**, including events of limited importance

Road Tunnels Safety Measures



Measures preventing the occurrence of significant incidents

- Adequate road **signage**
- Good quality tunnel **lighting**, reduce “black hole effect”
- **Optical lane guidance aids** (reflectors, LED marker lights)
- **Ventilation system** to ensure good air quality
- **Dynamic** warning signs
- **Electronic overhead signal** system
- **Overtaking prohibition**/implementation of **speed limits** and speed control
- Preventive **maintenance** (regular inspections, tests, cleaning)

Measures mitigating the consequences of significant events

- **Soften** the mechanical **impact** (safety barriers)
- Avoid **secondary collisions** (close one or more lanes or the tunnel)
- **Detection devices** for early warning of incidents
- **Verification devices** to confirm an incident has occurred
- **Automatic** fire-fighting devices
- Permanent supervision by a **control center**
- **Ventilation** system
- **Monitoring** system
- **Fire resistance** of equipment

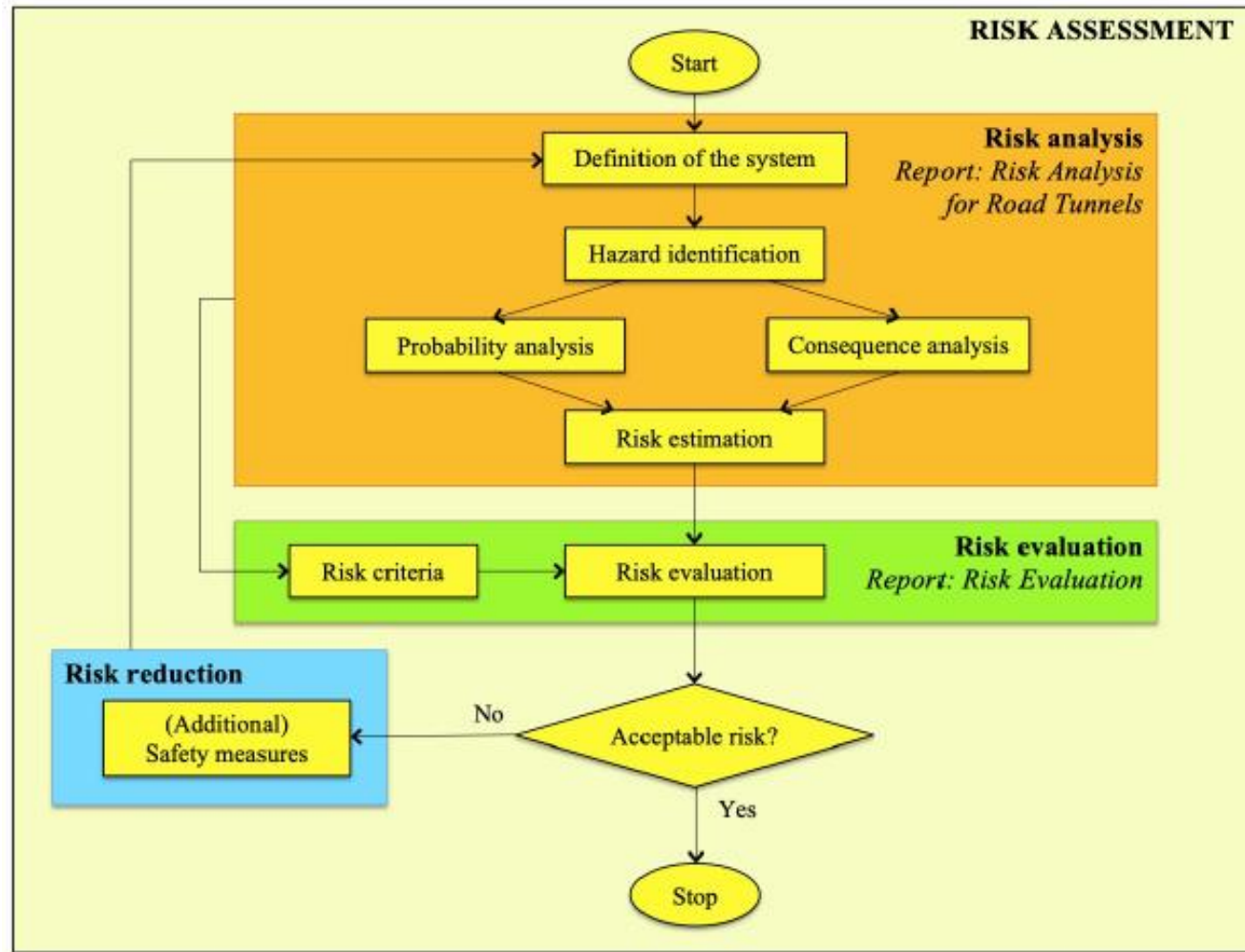
Measures supporting self-rescue

- Maximum admissible distance of emergency lanes leading to a **safe zone**
- **Smoke management** strategies
- Adequate **ventilation** system
- Safe **evacuation** passage **between tubes** in tunnels with two tubes operating with unidirectional traffic
- **Special attention** needed for tunnels with **high gradients**
- **Public education**, information campaigns

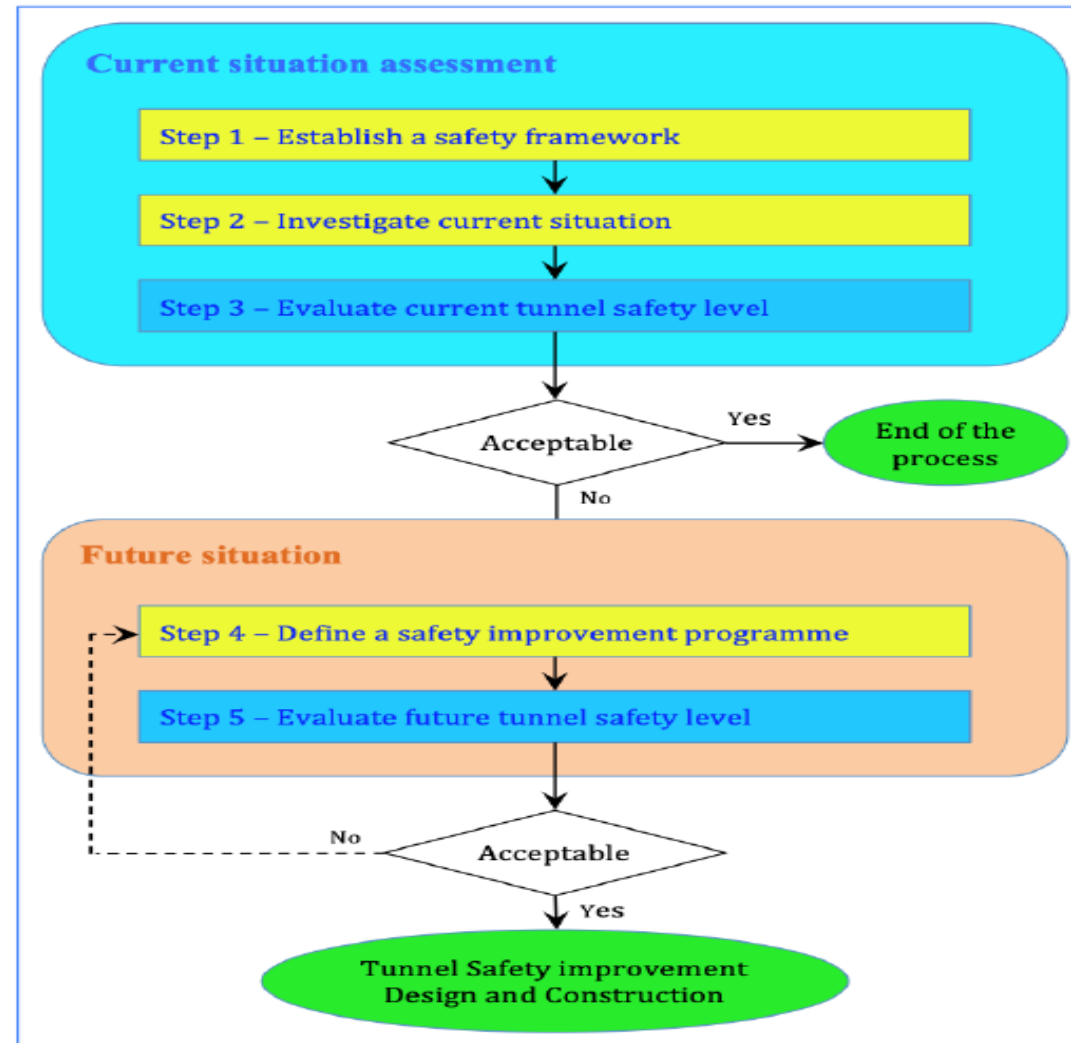
Measures supporting emergency response

- Complex because they **interact** with safety procedures and tunnel safety equipment as well as with human behavior involving tunnel operators and emergency organizations
- **Vehicle fires** are a particular concern, occurring quite often
- **Operators** need to **know their tunnels** well
- **Firefighters** need to have **basic training** in tunnel fires
- Establish **efficient cooperation** between operators and firefighters
- **Share knowledge** about the specific tunnels
- Keep **firefighters updated** on aspects relevant for safety

Risk assessment



Improving safety in existing tunnels



Recommendations



Road tunnels safety recommendations

- Adopt **integrated approach** during the design of road tunnels
- Important to take into account the **human factor**, behavior of tunnel users and tunnel operators.
- Establish the **safety concept** in an early design stage and provide it at all project stages.
- Ensure **cooperation** between operators and firefighting organizations
- Adopt measures for **prevention, mitigation, self-rescue and emergency**
- Ensure adopted **measures are well understood**
- **Upgrade existing tunnels**

PIARC IS BOOSTING ROAD SAFETY IN LMICs

- PIARC has responded to the need to bring together the experiences gained in the field of the **tunnel** operations, by addressing a range of issues related to the use of road tunnels.
- **PIARC Road Tunnels Manual** groups together, summarizes and updates the vast quantity of information contained in the various produced reports and articles.
- PIARC is engaged in **promoting road safety** all over the world and committed to **actively support safety in LMICs**.
- The new knowledge-sharing campaign for road safety will provide **monthly updates**, on social media and on PIARC website, for **all essential road safety areas**.
- **Stay tuned for more actions and events!!**



Relevant PIARC reports

- [PIARC ROAD TUNNELS MANUAL](#)
- [Technical report 2012 R23 “Current practice for risk evaluation for road tunnels”](#)
- [Technical report 05.16B “Systems and equipment for fire and smoke control in road tunnels”](#)
- [Technical report 2016 R35 “Experience with significant incidents in road tunnels”](#)
- [Technical report 05.04B “Road safety in Tunnels”](#)
- [Technical report 2008 R17 “Human factors and road tunnel safety regarding users”](#)
- [Technical report 2011 R04 “Recommendations regarding road tunnel drivers’ training and information”](#)
- [Technical report 2016 R06 “Improving safety in road tunnels through real-time communication with users”](#)
- [Technical report 2008 R03 “Management of the operator-emergency teams interface in road tunnels”](#)
- [Technical report 2019 R03EN “Prevention and mitigation of tunnel related collisions”](#)
- [Technical report 2008 R02 “Risk analysis for road tunnels”](#)
- [Technical report 2009 R08 “Safety inspections of road tunnels”](#)
- [Technical report 2012 R25EN “Best practice for road tunnel emergency exercises”](#)
- [Technical report 2007 R4 “Guide for organizing, recruiting and training road tunnel operating staff”](#)

Thank you for your attention!



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